INSTRUCTION MANUAL NO. E-949B

for the FAIRCHILD

TRANSISTOR DYNAMIC ANALYZER

Model 103A

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TEST CONSTRUCTION
ITEM 1 COPY 1
48 HOUR LOAN

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MA29948

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD
Guided Missiles Division
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TRANSISTOR DYNAMIC ANALYZER

MODEL 103A

The Fairchild Transistor Dynamic Analyzer provides the necessary circuitry to present 5 separate transistor characteristics on a cathode ray oscilloscope. These characteristics include:

1. Collector - (grounded base); V_c vs. I_c, I_e as parameter
2. Transfer; V_e vs. I_c, I_e as parameter *
3. Emitter; V_e vs. I_e, V_c as parameter
4. Alpha; α vs. I_e, V_c as parameter
5. Collector - (grounded emitter); V_c vs. I_c, I_b as parameter

All curves, in both the Manual and Auto. positions, are swept with a 60 $\sim$ sine wave. The trace is swept out and back in order to detect possible transistor hysteresis or instrument malfunction.

The outputs of the Transistor Dynamic Analyzer are from cathode followers, but due to the small signals involved during some measurements, it may be desirable to use shielded leads to the oscilloscope.

A sensitive, d-c cathode ray oscilloscope, such as the Dumont 304, must be used in conjunction with this instrument. **

The Analyzer is supplied with a transistor socket assembly which plugs directly into the panel. Two sockets are mounted in this unit, a special 3-contact socket for the Bell Labs. type of transistor case and a 5 pin, sub-miniature, in-line socket which will handle transistors having pigtails or in-line wire pins. The asymmetrically based units can also be mounted in this socket since the 3 inner pins are internally connected.

Preparatory to making any measurements, the following procedure must be followed:

PRELIMINARY ADJUSTMENTS

Connect two shielded cables from the VER and HOR outputs of the analyzer to the inputs of the cathode ray oscilloscope. The oscilloscope should be switched to the d-c amplifiers in both channels.

Adjust the two ZERO SET controls located at the back of the chassis to obtain zero voltage at the VERT. and HORIZ. outputs of the Analyzer. The oscilloscope can be used as the d-c null detector.

CALIBRATION

A simplified schematic of the calibration circuit is shown in Fig. 1. It consists of two sets

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* h_{12} characteristics may also be displayed. See page 3.

** The oscilloscope should be modified by reversing the connections to the horizontal deflection plates so that a positive voltage will give a deflection to the left.

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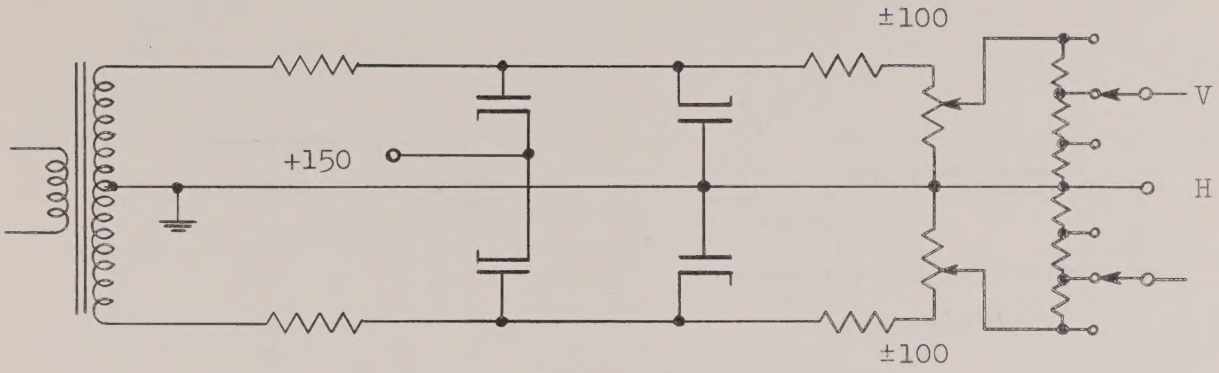

Figure 1

of biased diodes which are switched in four combinations by the CALIBRATE AXES switch. A voltage divider is used as a multiplier for the continuously variable diode biasing. Select the quadrant axes to be used by setting the CALIBRATE AXES switch to the appropriate position. These axes are particularly helpful when photographing a family of curves as they can be superimposed in the photograph. Depress the CALIBRATE lever switch and adjust the VERTICAL CALIBRATION and HORIZONTAL CALIBRATION according to the full scale deflections desired. When the graduated scale knob is rotated to its full scale clockwise position, the voltage from zero to peak will be 1, 10, or 100 volts according to the position of the adjacent switch. Although the scales are calibrated in volts, the horizontal trace will also read directly in milliamperes in the 1000 ohm, X1, position of the LOAD RESISTANCE switch. If the 100-ohm or 10-ohm load is used, the current as read by the calibrating dials must be multiplied by 10 or 100, respectively. The gain controls on the oscilloscope are then adjusted for a convenient trace length, such as 10 volts/inch, or 1 ma./inch, etc.

The C.R.O. is now calibrated and quantitative measurements may be taken.

AUTOMATIC FEATURE

The staircase-generator circuit which permits the simultaneous display of a family of curves is available for Collector Characteristics (grounded base or grounded emitter) and Transfer Characteristics. This feature permits the simultaneous display of six curves with the step size determined by the DECADE STEPS switch. Thus, the maximum emitter or base current is limited to 5 ma. or half that available in the MANUAL position.

COLLECTOR CHARACTERISTIC - (grounded base) Collector voltage vs. collector current.

A simplified schematic of this circuit is shown in Fig. 2. The emitter is biased positive or negative according to the transistor type from a 150 volt regulated source. The emitter bias current is varied by means of three front panel controls: UNIT STEPS, DECADE STEPS, BIAS CONTROL. The collector is fed through a full wave bridge rectifier from a 1:1 isolation transformer which

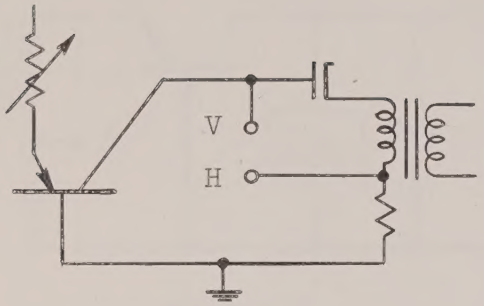

Figure 2

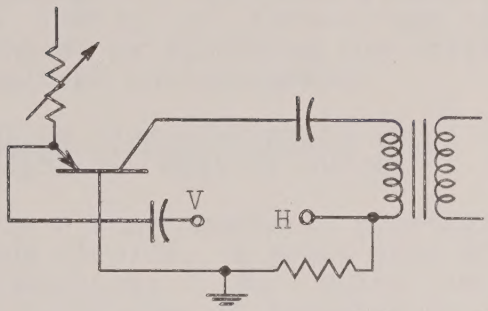

Figure 3

is in turn driven by a variable auto-transformer; AC VOLTAGE CONTROL. The voltage is taken at the collector and the current from across a resistor in the return circuit.

The slope of each curve thus taken is the collector resistance (r_c) at that point.

Operation

Switch the FUNCTION switch to the COL position, and set the DECADE STEPS switch which determines the magnitude of each step in the family when the UNIT STEPS switch is rotated. For example, if the DECADE STEPS switch is set to 0.2, the emitter current can be varied in ten 0.2 ma. steps from 0 to 2 ma. If intermediate positions are desired, set the UNIT STEPS Control to the position marked VAR., and rotate the BIAS CONTROL. The DECADE STEPS Switch determines the region covered by the BIAS CONTROL. The AC VOLTAGE CONTROL may now be slowly advanced, being careful to keep the trace within the predetermined limits. A family of curves can be obtained by rotating the UNIT STEPS switch in the MANUAL position, or by switching to AUTO in which case the UNIT STEPS switch is inoperative.

TRANSFER CHARACTERISTICS - Emitter voltage vs.collector current.

This circuit (see Fig. 3) is virtually the same as that used for taking collector characteristics. The ordinate voltage, however, is measured at the emitter rather than the collector. The slope of this curve is the base resistance which is generally referred to as R_{12}.

Operation

Move FUNCTION switch to TRANS position and proceed as for observing collector characteristics. The vertical gain control of the cathode ray oscilloscope will generally have to be increased for this measurement, due to the relatively small voltage across the emitter.

h_{12} CHARACTERISTICS -

h_{12} characteristics may be taken by setting up for collector (grounded base) measurements and picking off the signals for the oscilloscope at the collector and emitter.

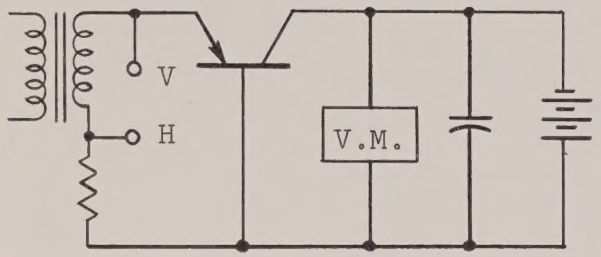

Figure 4

EMITTER CHARACTERISTICS (h_{11}) - Emitter voltage vs. emitter current.

The simplified schematic is shown in Fig. 4. The sweep voltage is applied to the emitter, and the collector is held at a constant voltage by means of an 80 μf capacitor. The slope of this curve is equal to the input resistance of the transistor with the collector short circuited. The measurement also shows immediately the short-circuit stability of a point contact transistor. A unit which is short-circuit unstable will exhibit a negative slope over some portion of this curve.

Operation

With the A-C VOLTAGE CONTROL and D-C VOLTAGE CONTROL set to zero, move the FUNCTION switch to the EMIT position. Adjust the D-C VOLTAGE CONTROL to the desired collector voltage which is read directly from the panel meter on either of the two scales. Slowly advance the A-C VOLTAGE CONTROL until the desired sweep amplitude is obtained. It is important to note that the display will be either in the first or third quadrants and rather high gain is necessary to observe the emitter voltage in the forward direction. A family of curves may be obtained by adjusting the collector voltage in increments.

ALPHA CHARACTERISTICS (h_{21}) - Alpha vs. emitter current

The α characteristic provides, in one display, a great deal of information. For point contact transistors, it immediately shows up any instabilities and measures α at any emitter current up to 10 ma. and any collector voltage up to 100 volts. The speed of α rise at small currents can also be correlated with the switching speed of the transistor. For junctions, it provides an accurate, 1%, measurement of the current gain and due to the precision of the alpha measurement, beta may be computed with good accuracy from the expression $\beta = \frac{\alpha}{1-\alpha}$. As with the other measurements, the sweep is 60~, swept in both directions, and the signal frequency is 50 kc. Virtually all transistors show a flat response up to and beyond this frequency when the grounded base connection is used.

Fig. 5 shows the operation of the circuit. The emitter sweep current is obtained from a 1:1 isolation transformer in series with a set of fixed resistors (DECADE STEPS). The 50-kc signal is superimposed on this current from a 100-K-ohm source impedance. The output is taken from across a 100-Ω precision potentiometer in the collector circuit. It is then amplified in a band-pass amplifier and rectified to give the pattern on the oscilloscope. For calibration, the double pole switch is moved to the down position, and the 50-kc signal is now

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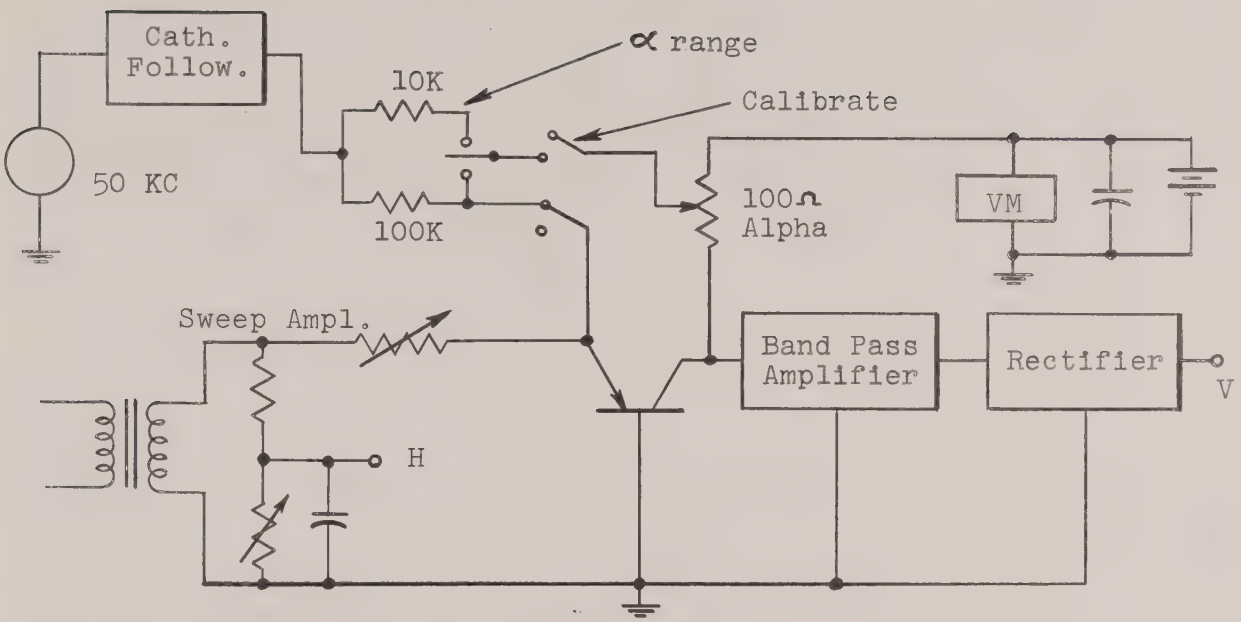

Figure 5

connected to the arm of the pot. through the same 100-K resistor. This provides a maximum scale of unity for junction transistors. For point contact transistors, the 10-K resistor is switched in and the maximum reading is 10. The H deflection is taken from a compensated voltage divider which can be adjusted to eliminate hysteresis due to phase shifts in the external equipment.

Operation

Set the FUNCTION switch to the ALPHA position and adjust the D-C VOLTAGE CONTROL to obtain the desired collector voltage as observed on the panel meter. Note that the actual voltage on the transistor will differ from the meter reading by the voltage drop in the 100-Ω collector load. Next adjust the DECADE STEPS switch to the appropriate emitter sweep amplitude which is 10 times the indicated values. For example, if a maximum sweep of 2 ma. is required, set the switch to the 0.2 position. The emitter current will then sweep out to 2 ma. In order to correct for differences in phase, the phase adjust control at the back should be adjusted to eliminate hysteresis.

To measure alpha at a particular value of emitter current, move the trace horizontally so that this current corresponds to a mark on the reticule. Switch the ALPHA RANGE switch to the "1" position when measuring a junction transistor, or "10" when measuring point contact transistors. (Transistors having a current gain greater than 10 can also be measured as explained below.) Now press the ALPHA CAL lever switch which will cause the unmodulated 50-kc carrier to appear on the oscilloscope.

Adjust the vertical amplitude of this trace by varying the ALPHA potentiometer until it is exactly equal to the amplitude of the trace at the predetermined emitter current. The lever switch can be depressed several times in rapid succession in order to obtain an accurate reading and minimize any drift in the oscilloscope.

To obtain the zero emitter current point, of the α trace, reduce the oscilloscope horizontal gain to zero. This point or line corresponds to zero emitter current.

The amplitude of the α traces may vary somewhat as the sweep amplitude (DECADE STEPS) is varied, but this is not an instrument error. In order to maintain optimum signal to noise ratio, the probe current which is fed to the emitter is varied with the sweep and the amplifier gain is roughly tracked to maintain a reasonably constant image size.

To measure α greater than 10, adjust the oscilloscope vertical gain so that the α waveform is an integral number of units high and adjust the ALPHA potentiometer to a fraction of this amplitude. The current gain will be the reading on the potentiometer multiplied by the reciprocal of this fraction.

At signal levels corresponding to alphas of less than 0.5, the rectifiers do not operate linearly. This does not affect the accuracy of the calibration since the amplitudes of both the signal and calibration are equal during calibration. When measuring current gains greater than 10, the non-

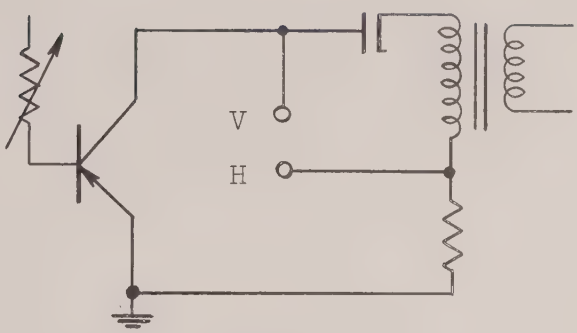

Figure 6

linearity is negligible and although the signal and calibration trace are not equal in amplitude, there is virtually no error from this cause.

COLLECTOR CHARACTERISTIC - (grounded emitter) Collector voltage vs. collector current

The circuit is similar to that used in the grounded base measurement (see Fig. 6).

The user is cautioned to start the DECADE STEPS switch in the minimum step position to avoid damage to transistors. The collector supply is capable of handling 250 ma. or more. An external, high impedance current source can be used if base currents of more than 10 ma. are required.

Operation

Move the FUNCTION switch to the COL GND EMIT position and return the AC VOLTAGE control to ZERO and the DECADE STEPS selector to the .02 position. Slowly advance the AC VOLTAGE control until sufficient voltage has been applied. The DECADE STEPS switch may be advanced, taking care that the

transistor current rating is not exceeded. When high collector currents are to be used the LOAD RESISTANCE will need to be reduced to 100Ω or 10Ω in extreme cases.

Manual or automatic presentation is available as described previously.

Internal Adjustments

There are several additional adjustments which are available on the chassis. These are preset at the factory and normally require no attention. However, when replacing vacuum tubes or other major components, these adjustments should be checked.

LOCATED ON TOP SIDE OF CHASSIS

Axis Calibration

Two screw driver adjust potentiometers are located together on the top of the chassis. These should be adjusted with the front panel calibrating switches in the "10" position and the calibrating potentiometers in the maximum clockwise position. The trace on the oscilloscope is then compared with a 10 volt d-c source and the chassis adjustments made until the trace lengths are equal.

Alpha Calibration

This control is for the purpose of adjusting the alpha calibration in the "10" position. No adjustments are required for the "1" position. The procedure for making this adjustment is simply to compare an alpha setting of unity in the "10" position with the unity setting in the "1" position as the standard.

Step Size

This control is adjusted to give 75 volts for the staircase across the emitter-base terminals in the COL position under open circuit conditions.

AT BACK OF CHASSIS

Hysteresis

This controls the phase in the ALPHA position only. Adjust to eliminate hysteresis.

Step Lock

Adjust this control for synchronization in the AUTO. position.

Zero Reference

This adjustment is to establish the bottom step at zero in the AUTO position. Adjust for zero volts across the emitter-base terminals under open circuit conditions for the bottom step.

VERTICAL and HORIZONTAL Zero

These control the d-c levels at the HORIZ. and VERT. outputs. They should be adjusted for zero volts with no signal.

SPECIFICATIONS

ALPHA CHARACTERISTIC (α vs. i_e)

Alpha Range	0-1 (±1%)
	0-10 (±2%)
Sweep Length	0.2 ma
	0.5 ma
	2.0 ma
	5.0 ma
	10.0 ma
Collector Voltage	continuously variable
	0-100 volts

COLLECTOR CHARACTERISTIC (e_c vs. i_c) grounded emitter or base

Base or Emitter Current, respectively
- manual - 10 equal increments
- auto. - 5 equal increments

Size of Increment	20 μa
	50 μa
	200 μa
	500 μa
	1000 μa

Interpolation available between increments in MANUAL Position.

Maximum Collector sweep voltage 100 volts

Maximum Collector current 250 ma.

TRANSFER CHARACTERISTIC (e_e vs. i_e)

Same as COLLECTOR CHARACTERISTIC

EMITTER CHARACTERISTIC (e_e vs. i_e)

Collector Voltage 0-100 volts

DEVICES TESTED

Transistors
- Point Contact type N or P
- Junction type NPN or PNP

Diodes
- Point contact and junction, ge or si
- Adaptable to field effect and tetrode transistors.

LOAD RESISTANCE

10, 100, 1000 ohms.

CALIBRATION

Available in both axes

Voltage	0-1, 10, 100 volts
Current	0-1, 10, 100 ma.

Current ranges multiplied by 10 or 100 in 100-Ω and 10-Ω load positions, respectively.

SWEEP FREQUENCY AND WAVEFORM

60 c.p.s., sine wave (includes retrace in all positions, manual and automatic)

OUTPUT IMPEDANCE

Low-cathode follower in both outputs. No shielding required.

METER

Voltmeter to measure collector volts 10, 100.

GENERAL

Power Supply
105-125 volts - 60 cps - 90 watts

Weight
35 lbs.

Dimensions
- Hardwood Cabinet 20" x 13-1/2" x 10"
- Standard Size Panel 19" x 12-1/4"

SPECIFICATIONS (continued)

Equipment Supplied

Transistor plug-in assembly. Contains two sockets wired in parallel to accept point contact and junction transistors. Additional sockets easily added.

Accessories

D-c oscilloscope. Not supplied.

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